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**VOICE COMMUNICATIONS EFFECTIVENESS OF THE ALL-PURPOSE
MCU-2 /P CHEMICAL DEFENSE PROTECTIVE MASK**

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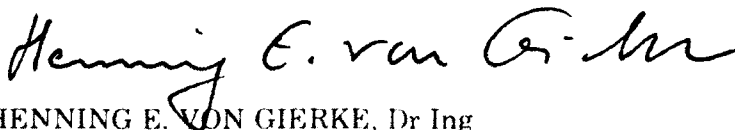
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FOR THE COMMANDER



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ABSTRACT

The voice communications effectiveness of the all-purpose MCU-2/P chemical defense protective mask for use by all ground personnel was evaluated in a laboratory study. Speech intelligibility was measured for the MCU-2/P under face-to-face communications conditions and when interfaced with a commercial telephone handset, a security police "walkie-talkie" handset and the H-133 ground communications headset-microphone unit. These communications configurations were evaluated in selected noise environments that ranged from 77 dB to 115 dB sound pressure level (SPL) re 20µPa. The MCU-2/P mask and hood exhibited good speech intelligibility for all communication configurations in the 77 dB noise condition. However, voice communication was not satisfactory for personnel wearing the mask and hood under the same communications situations in the higher levels of the noise. Factors that contributed to or caused the voice communications to be unsatisfactory are discussed in the report.

PREFACE

This research was accomplished in the Biological Acoustics Branch, Biodynamics and Bioengineering Division, Air Force Aerospace Medical Research Laboratory, Aerospace Medical Division (AMD). The effort was accomplished under Project 7231, "Biomechanics in Aerospace Operations". Task 723120, "Biodynamics and Bioengineering Support", Work Unit 72312003, "Technology Applications". Lt. William Decker was Project Officer for this effort. This work was supported in part by the Life Support SPO, ASD/AEEE and by the AMD Chemical Defense Project 2729, Work Unit 27290901, "Chemical Defense Audio Communications".

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MCU-2/P CHEMICAL DEFENSE PROTECTIVE MASK
VOICE COMMUNICATION CAPABILITY

INTRODUCTION

Several factors in Chemical-Biological-Radiological (CBR) environments may substantially reduce the sustained effective task performance required for mission accomplishment. Primary factors are the agents and antidotes themselves, however the personal equipment essential for protection may also interfere with the capability to accomplish mission objectives. Voice communications effectiveness is one important performance capability that has been degraded to varying degrees by some of the CBR ensembles, masks and hoods. In order to insure that equipments with deficient voice communications features are not deployed in the field, the voice communications features of CBR equipments must be measured to identify those systems providing satisfactory voice communications as well as those with deficiencies that require improvements to achieve acceptable communications.

General criteria or standards should require that the mask permit intelligible voice transmission and reception and should not interfere with hearing under typical use conditions. The mask should permit the use of receiving and transmitting communications devices currently in use and

those expected to be fielded in the near term by the military. The hood should not degrade voice transmission or reception features of the mask. It is highly desirable that the standard require a level of voice communications performance as defined by a standard speech intelligibility measure, such as 75% correct or above on the Modified Rhyme Test.¹

PURPOSE

This report describes a laboratory investigation of the voice communications characteristics of the MCU-2/P chemical defense protective mask. The mask was examined under various voice communications and environmental noise conditions that would be experienced in the field. Data are analyzed and discussed in terms of the adequacy of the voice communications of personnel wearing the mask. The purpose of this study is to provide voice communications performance data for personnel wearing the MCU-2/P mask and hood in a variety of typical situations and noise environments.

CHEMICAL DEFENSE PROTECTIVE MASK MCU-2/P

The MCU-2/P is an all-purpose chemical defense protective mask designed for use by the full range of ground personnel in Air Force operational environments that includes air traffic controllers, military police, emergency

teams and ground maintenance personnel. The MCU-2/P mask, shown in Figure 1 with and without the protective hood, consists of a total face enclosure mask that is retained on the head by a web of elastic straps. Vision is accomplished through a large visor. Inspired air enters the mask through a canister filter to the left side of the mask and air is expired through an outlet valve in the lower front of the mask. The mask contains two voicemitters designed to provide a voice communications capability. The small diameter voicemitter located on the right side of the mask is designed for use with a standard commercial telephone handset. The large diameter voicemitter, located in the front of the mask, is designed primarily for use in face-to-face communications. It is also used for communications using equipment such as the "walkie-talkie". The mask also contains a drinking tube. A protective hood is worn to cover those portions of the head not covered by the mask.

APPROACH

The speech intelligibility of volunteer subjects wearing the MCU-2/P mask was measured in four different communication configurations in relative quiet and in various levels of emulated operational noise. Volunteers performed as talkers and listeners under the same noise conditions transmitting and receiving standard

intelligibility test materials. Criterion measures were percent correct responses of the intelligibility measures.

Communications Configurations

The four communication configuration conditions measured in this study were as follows.

(1). Face-to-face situations where the talker wore the MCU-2/P mask and communicated with nearby personnel who also wore the MCU-2/P mask. This was accomplished with the communicators at different separation distances and with communicators facing one another.

(2). Talkers and listeners wore the MCU-2/P masks and communicated using the standard commercial telephone handset interfaced with the small voicemitter.

(3). Talkers and listeners wore the MCU-2/P masks and communicated with the security police hand-held "walkie-talkie" interfaced with the large voicemitter.

(4). Talkers and listeners wore the MCU-2/P mask and the H-133 ground communications headset and the talker spoke into the "tear-drop" microphone noise shield held tightly against the large voicemitter.

EQUIPMENT AND MATERIALS

Experimental Subjects

Ten volunteer subjects trained in voice communications effectiveness studies participated in this investigation. All were recruited from the general civilian population and were paid an hourly rate for their participation. All subjects exhibited normal hearing, hearing levels no greater than 15 dB, at the standard audiometric test frequencies from 500 Hz to 6000 Hz.² These experienced subjects were fully trained on the requirements of this investigation prior to data collection.

The natural speech produced by these subjects was general mid-western American speech; none exhibited a noticeable accent, dialect or speech problem. Five of the subjects, three males and two females, participated as trained talkers. All ten subjects participated as listeners with each communication configuration requiring a different number of listeners to complete that portion of the study (see experimental procedure).

Voice Communication Research And Evaluation System

This investigation was accomplished using the Voice Communication Research and Evaluation System (VOCRES) at the

Air Force Aerospace Medical Research Laboratory, Wright-Patterson AFB.³ This system and its operation contain the operator, system and environment variables known to most directly affect voice communications (Figure 2). VOCRES consists of a central processing unit that controls the experimental sessions and ten individual communication stations each equipped with a 64 character alphanumeric light emitting diode (LED) display, a subject response unit consisting of special keyboards for inputting performance responses to the central processor, and a large volume unit (VU) meter that indicates voice level of speech produced at that station. Each station also contains the standard AIC-25 aircraft intercommunication system, the Air Force standard voice communications headgear, an air respiration system with an A-14 manual diluter demand regulator and an AF standard oxygen mask. The VOCRES central processing unit provides real time response measurement, performance display, data collection and reduction. A programmable high intensity sound system is used for emulating operational noise environments in the laboratory.

High Intensity Sound System

The high intensity sound system is a versatile electrodynamic system that permits the accurate reproduction in the laboratory of ambient and environmental noise conditions of operational situations ranging from C³ centers

to cockpits of high performance tactical aircraft. A noise generator and spectrum shaper allow most of these military noise environments (spectrum and level) within the 20 Hz to 20 kHz frequency range to be generated inside the VOCRES facility.

Evaluations in this investigation were accomplished in two different noise environments. A broad band noise with a reasonably flat spectrum was utilized for the ambient noise condition at 77 dB sound pressure level (SPL) re 20uPa. The far-field noise environment of an F-15A tactical aircraft with both engines at 80% RPM was measured at a distance of 73 meters from the aircraft. The spectrum of this measured noise environment, as shown in Figure 3, was emulated in the laboratory and produced at levels of 95 dB, 105 dB and 115 dB for the speech intelligibility tests. The various voice communications configurations were evaluated in selected levels of the operational noise environments (Table 1).

Intelligibility Test Materials

Speech communication was measured in this study using the standard intelligibility test, the Modified Rhyme Test (MRT).¹ The MRT is considered the test of choice for evaluating the performance of military communications equipment. The materials consist of word lists that are essentially equivalent in intelligibility, with each list

consisting of 50 one-syllable words. During this study using VOCRES, the talker spoke a test word embedded in the standard carrier phrase, "Number ..., you will mark _____, please." The listeners then selected from a set of six words displayed at each station, that word that was believed to have been spoken by the talker. The intelligibility score for that word list was the average percent correct for the number of listeners participating in that phase of the study. The scores were adjusted for correct answers obtained by guessing and expressed as percent correct. The MRT is easy to administer, score and evaluate and it does not require extensive training of the subjects.

PERFORMANCE CRITERIA

The standard intelligibility measure (MRT) has been used in the VOCRES facility for numerous investigation of communications systems and components. Performance in the laboratory reportedly has been very similar to that subsequently experienced in operational situations. On the basis of these data and experiences, a set of criterion measures of the laboratory data has been adopted as a predictor of expected performance in the operational situation. Systems and components that perform in VOCRES at an intelligibility level of about 70% and below are not acceptable for operational applications. Those with

performance in the range from 70% to 80% are considered marginal and their success in the field depends upon the specific conditions under which they are implemented. Equipments exhibiting intelligibility performance at about 80% and above are considered fully acceptable under operational conditions. The MCU-2/P mask will be evaluated relative to these criteria.

PSYCHOACOUSTIC EXPERIMENTAL PROCEDURE

The MCU-2/P chemical defense protective mask was investigated for voice communications effectiveness under the four communications configurations described earlier. Each configuration required a different test procedure that varied in number of subjects, positioning of subjects, and number of noise levels experienced by the subjects (Table 1).

Face-to-Face Communication

Subjects wore the MCU-2/P mask with and without the protective hood in the face-to-face communications evaluation. The paradigm consisted of one talker speaking to three listeners. Five different subjects, three male and two female, participated as talkers. The talker was separated from the listeners by distances of three feet and of ten feet. During this evaluation both talkers and

listeners were in the noise condition at levels of 77 dB, 95 dB and 105 dB (Figure 4). The talker spoke the key words at his position and the listeners responded by depressing appropriate response keys at three of the VOCRES stations. The talkers recited two MRT word lists for each condition while facing the listeners at the three feet and ten feet separation distances.

Talkers and listeners were instructed to use whatever vocal effort was required to achieve satisfactory voice communications. They were asked to perform as if they were working in a noise environment such as an aircraft flight line. Talkers used a raised level speaking voice for most of the lower noise level and close separation distance conditions, however subjects used a "shouting" voice at the highest noise level and ten feet separation distance.

In a baseline condition neither talker nor listeners wore the MCU-2/P mask and/or hood. In condition 1, both talker and listeners wore the MCU-2/P mask but the protective hood was not worn. In condition 2, both the talker and listeners wore both the mask and the hood.

The subjects wore only the mask and hood combination described above for the noise conditions at 77 dB and 95 dB. The length of exposure to the 105 dB noise condition would have exceeded the allowable daily exposure as specified in

AFR 161-35, Hazardous Noise Exposure.⁵ Consequently, the subjects were required to wear hearing protection as would be the case in operational situations. The subjects wore a standard AF earmuff hearing protector in addition to the MCU-2/P mask and hood for these measurements.

Commercial Telephone Handset Interface

Subjects wore both the MCU-2/P mask and protective hood for measurements using the MRT of voice communications over standard commercial telephone handsets. Two subjects fitted with the mask and hood participated in each test session. One subject communicated the MRT words over the telephone handset and the other listened to the message. The two subjects were separated by a distance of ten feet and positioned so that they were unable to view the face of the other subject. Three male and two female subjects participated as talkers in these sessions. This procedure was repeated for the five talkers, each reciting one MRT word list individually to five different listeners. These communications were measured in noise levels of 77 dB and 95 dB.

The microphone portion of the telephone handset was positioned directly over the small voicemitter at the right side of the mask (Figure 5). The talker maintained a tight coupling of the mouthpiece to the voicemitter during the

measurement sessions. The earpiece was positioned over the ear of the listener resting on the protective hood worn by the listener.

"Walkie-Talkie" Handset Interface

The speech intelligibility performance of the MCU-2/P mask when communicating over the security police "walkie-talkie" was measured with the same paradigm as that used with the telephone handset. The only difference in procedure consisted of placing the microphone of the "walkie-talkie" over the large voicemitter at the front of the mask instead of the small voicemitter used with the telephone handset. As seen in Figure 6, the "walkie-talkie" could not be closely interfaced with the large voicemitter on the mask. The earpiece of the "walkie-talkie" was positioned over the ear of the listener and the protective hood.

H-133 Ground Communications Headset Interface

Talkers and listeners wore the H-133 ground communications headset with the MCU-2/P mask and hood for these measurements. The headphones were placed over the hood and ears of all of the subjects for these measurements. The talker positioned the tear-drop noise shield, which contained the standard M-101 noise cancelling microphone,

directly over the large voicemitter at the front of the MCU-2/P (Figure 7). Communications took place from the talker over the standard AF AIC-25 intercommunication system to the listeners in the noise environments. Two male talkers and one female talker each recited two MRT word lists in each of four noise conditions of 77 dB, 95 dB, 105 dB and 115 dB. Nine listeners responded to the speech materials received over the headphones.

PSYCHOACOUSTIC RESULTS

Overall, satisfactory voice communications with the MCU-2/P mask and hood were obtained only in the low level noise conditions of this investigation. Speech intelligibility progressively decreased as the levels of the noise conditions were increased until communication was totally unsatisfactory at the highest level noise conditions.

Face-to-Face Communications.

Percent correct intelligibility scores are presented as a function of communication configuration, separation distance and noise condition in Figure 8. Speech communications were satisfactory in the baseline condition with intelligibility scores of 80% and better except for the marginal performance at the separation distance of ten feet

in the 105 dB level of noise. The MCU-2/P configurations with and without the hood showed good communications for the 77 dB noise condition, however intelligibility is considered unsatisfactory for the 95 dB and 105 dB conditions at both separation distances.

Subjects wore an Air Force standard earmuff sound protector during the 105 dB noise conditions. Consequently, the measured speech communication performance was affected by the earmuff device in combination with the mask and hood. Personnel are prohibited from wearing the mask and hood without hearing protection in the operational situation for the durations and highest level of noise used in this communication configuration. The 105 dB noise condition with earmuff hearing protection was measured to demonstrate the performance expected in an operational situation.

In virtually all measurements, the speech intelligibility was less at the ten than at the three feet separation distance. Differences ranged from about 2% to 9% and were greater for 95 dB and 105 dB than for the 77 dB noise condition. Intelligibility scores were only slightly less for the mask with hood measurements than for the mask without hood values.

Intelligibility for all face-to-face conditions was

adversely affected by the noise exposures. The greatest reductions occurred for the mask conditions which showed a drop from the baseline data of about 40% for the 95 dB and 50% for the 105 dB noise conditions. The mask conditions in the higher level noises exhibited speech intelligibility scores of about 40% and less for all conditions. Raw data for the face-to-face conditions are contained in Table 2.

Commercial Telephone Handset

Data for the voice communication performance of the telephone handset and the "walkie-talkie" handset in the noise environs is summarized in Figure 9. Telephone handset voice communications were quite good with the mask and hood in the 77 dB noise condition. The intelligibility dropped from 94% at 77 dB to 69% correct at the 95 dB level of noise. The standard deviation values of $\pm 10\%$ were more than double those measured in the 77 dB noise. Raw data for the telephone handset and "walkie-talkie" interfaces are contained in Table 3.

"Walkie-Talkie" Handset

Speech intelligibility data for the "walkie-talkie" handset in noise is also shown in Figure 9. Voice communications were satisfactory in the 77 dB noise but dropped to 64% in the 95 dB noise condition. As with the

telephone handset, the standard deviations for the 95 dB noise were about double the values measured in the 77 dB condition. Subjects wearing the MCU-2/P mask and hood displayed somewhat better intelligibility when interfacing with the commercial telephone handset than with the "walkie-talkie handset". However, both instruments provided satisfactory communications in the 77 dB noise and unsatisfactory communications in the 95 dB noise.

H-133 Ground Communication Headset

The communications capability of the MCU-2/P mask and hood using the standard Air Force H-133 ground communications headset over the AIC-25 intercommunication system in four different noise environments is summarized in Figure 10. Performance is shown as mean percent correct intelligibility and standard deviation scores. Satisfactory voice communications were measured in the two lower level noise conditions of 77 dB and 95 dB. Communications were marginal to unsatisfactory in the 105 dB noise and clearly unsatisfactory in the 115 dB noise. At noise levels above 95 dB, the percent correct intelligibility decreased about 15% for each 10 dB increase in the level of the noise environment. Standard deviation values were reasonably small except for the 105 dB condition where they were double the value of those for the other noise conditions.

The H-133 ground communications headset-microphone unit is designed to provide acceptable voice communications in noise levels of up to about 135 dB. The unit typically provides satisfactory communications in the field in all except some test cell type environments. This study shows that the MCU-2/P mask and hood interface with the H-133 unit results in a significant reduction in voice communications capability for the H-133 unit at the level of 115 dB. The communications capability with these systems in the field is expected to be seriously deficient at noise levels above 115 dB that are experienced in typical aircraft ground maintenance activities. Raw data for the ground communications headset is contained in Table 4.

ELECTROACOUSTIC PROCEDURES AND RESULTS

Voicemitter Speech Spectrograms

The acoustic signals of speech produced through the voicemitters of the MCU-2/P were compared to those of natural speech by means of the speech spectrogram. One talker spoke the phrase "Joe took father's shoe bench out" into the microphone of the speech analysis unit of a Symbolics 3470 computer. The talker repeated the phrase, while wearing the MCU-2/P mask, which was also recorded with the computer input microphone positioned at each of the two voicemitters. Spectrographic analyses of these recordings

were performed by the computer. The relative acoustic features of the three speech signals are displayed in the spectrograms in Figure 11. The spectrogram displays a speech signal in terms of frequency, intensity and duration. Frequency is displayed along the ordinate (0 to 8000 Hz), time duration along the abscissa (0 to 2 seconds) and the intensity is represented by the relative darkness or density of the display. The vowel sounds appear along the lower portion of the panels and the consonant sounds in the middle and upper regions of the panels.

The acoustic features of the natural speech signal are displayed in the top panel of Figure 11. The spectrogram for the large voicemitter is displayed on the middle panel and for the small voicemitter in the bottom panel. One observation of the information in these panels is that the high frequency energy that comprises the consonant sounds is not effectively transmitted by the two voicemitters. There is a relatively large amount of signal that is lost or not transmitted by the larger voicemitter and even a greater loss of signal by the smaller unit.

The intelligibility of speech is determined in large part by the information contained in the consonants. Although relatively large amounts of consonant energy were lost through the voicemitters, the intelligibility in quiet environments was satisfactory. However, intelligibility

deteriorated rapidly in noise indicating that the missing high frequency energy may have made the remaining acoustic energy of the voicemitter speech more susceptible to masking by noise than natural speech.

Another observation is that the vowel sounds in the lower portions of the panels, unlike the consonant energy, appeared to be effectively transmitted by the voicemitters with some of the areas appearing to be slightly reinforced by the voicemitters. There are other changes between the natural speech and voicemitter spectrograms that are best revealed by analysis instead of observation, however the major change affecting voice communications effectiveness appears to be the failure of the voicemitters to transmit the high frequency energy. The acoustic features that contribute to voicemitter speech quality, which differs from natural speech quality is not apparent from general observation of the spectrograms.

Voicemitter Frequency Response

The frequency responses of the two voicemitters were measured in an anechoic chamber with the instrumentation arrangement shown in Figure 12. The computer controlled the function generator, amplifier and artificial voice in generating the acoustic test signal. The artificial voice was contained in a head form. The response of the

artificial voice was recorded, analyzed and plotted by the microphone, true RMS voltmeter and computer system. This initial plot served as the reference response of the system.

The MCU-2/P mask was placed on the headform with the artificial voice positioned directly in front of the large voicemitter, in the same position as occupied by the lips and mouth of a wearer of the mask. The signal output of the artificial voice was maintained at 105 dB SPL re 20 uPa for all measurement conditions. The recording microphone was positioned directly in front of the large voicemitter for one set of measurements and in front of the small voicemitter for another set of measurements. The microphone response was corrected for the different artificial voice-microphone separation distances of the measurements taken with and without the MCU-2/P mask on the headform.

A plot of the frequency responses of the voicemitters as a function of relative amplitude of the signals is presented in Figure 13. The responses were normalized and presented on the same graph to facilitate inspection and comparison of the data. The main feature of these data is the relatively large loss of energy across most of the audio frequency speech spectrum. The small voicemitter shows 5 to 10 decibels more energy loss than the large voicemitter in several of the frequency regions. These frequency responses

do not reveal distortions of the signal that might be caused by the voicemitters.

The data in Figure 13 confirm the loss of high frequency energy that was demonstrated in the speech spectrograms with the poorer quality smaller voicemitter indicating the greater loss of energy. As noted earlier, much of the intelligibility is carried in the high frequencies and it is easy to understand how noise can displace this energy and result in degraded intelligibility. Information provided by electroacoustic measurements is best suited to the design and modification of voicemitters to improve voice communications effectiveness.

DISCUSSION

Satisfactory voice communications performance was achieved with the MCU-2/P chemical defense protective mask and hood in the relatively quiet noise environment of 77 dB SPL. However, it is clear from the data obtained during this investigation that the voice communications capability for personnel wearing the mask and hood in the conditions studied is degraded to an unsatisfactory degree by the noise environs in which they operate. Reasons for this lack of adequate voice communications differ depending on the communications configuration and the interface with the mask and hood.

a. The overriding factor of the unsatisfactory voice communications in the various conditions with the MCU-2/P was the masking effect on the speech signal by the ambient noise conditions. Although other factors degraded audio communications, none produced as much interference as the noise.

b. The hood may interfere with the accomplishment of a good acoustic seal at the ear when using communications headsets and handsets. This becomes significant when these devices are used with the mask and hood in high level noise environments and masking noise reaches the ears of the listener.

c. Some voice communications effectiveness is lost when the MCU-2/P mask is used with the voicemitters interfacing with handsets and headsets. This loss is caused by an inability of the communication interface to capture the best speech signal from the voicemitter and by the introduction of masking noise across the mask-communications units interface. (a). The telephone handset fits reasonably well against the small voicemitter. (b). The "walkie-talkie" does not couple directly to the large voicemitter and must be held at an angle to the side of the mask for voice communication. In this position the full level of the ambient noise field appears at the surface of the voicemitter. The performance of the telephone handset

was better than that of the the walkie-talkie. (c). The M-101 microphone "tear drop" noise shield fits snugly over either the large or small voicemitter when held tightly in place by the talker. Although the coupling is good from the standpoint of noise exclusion, it appears that the noise cancellation features of the microphone ("kiss to talk") may not be realized in this interface.

d. The mask and hood provide some attenuation of the airborne sidetone of the speech signal produced by the talker in both the face-to-face and communication systems conditions. This reduced sidetone causes the talker to speak with a raised voice to produce a level of sidetone that appears to be normal to the talker. When the ambient noise combines with the mask to significantly reduce the sidetone, the talker must frequently shout to be understood. Although a shouting voice may provide a reasonable sidetone signal and improve the speech signal to noise ratio, it also may introduce distortions in the speech signal.

e. Face-to-face voice communications are known to be facilitated by information cues from the faces of the talkers. The MCU-2/P mask virtually eliminates these facial cues and their information content by completely covering the lower portion of the face. In the relative quiet of 77 dB, the speech signal could be clearly perceived and the additional information provided by facial cues was not

needed for comprehension. However, the decreases in intelligibility while wearing the mask in 95 dB and 105 dB include the effects of loss of information typically provided by facial cues. Also, the eye contact typically used in face-to-face communications to provide feedback to the talker that the communication link is intact, may be lost when the eyes of the communicators are prevented from being seen by one another by factors ranging from light glaring off the visor to inadequate light conditions.

f. The talkers voice is altered by the voicemitters; however, the quality is only slightly affected and the intelligibility remains very good in relative quiet. Subjectively, the quality of speech from the large voicemitter appears better than that from the smaller device which seems to be somewhat muffled.

g. The communication signal presented to the listener is slightly attenuated by the hood; the mask does not cover the ears. In the various communications configurations evaluated in this study this effect was minor and it should not be an issue except in very marginal communications situations.

CONCLUSIONS

The following conclusions are derived from the results of this investigation of the voice communications effectiveness of the MCU-2/P chemical defense protection mask and hood as well as from the voice communications performance criteria cited earlier in this report.

1. In the face-to-face voice communications configuration, the MCU-2/P mask and hood exhibited good performance in the low level noise of 77 dB SPL re 20uPa. This performance was only 10% worse than the scores of subjects communicating under the same conditions without wearing either the mask or the hood. However, in noise levels of 95 dB and 105 dB the voice communications were clearly unsatisfactory.

2. Voice communications were satisfactory with both the commercial telephone and security police "walkie-talkie" handsets in the 77 dB noise condition. The performance of both handsets was unsatisfactory in the 95 dB noise condition. Performance of the telephone handset was slightly better than the "walkie-talkie" in both levels of the noise.

3. Voice communications with the H-133 ground communications headset-microphone unit worn with the MCU-2/P mask and hood were satisfactory in both the 77 dB and 95 dB noise conditions. The percent correct intelligibility

decreased 15% for each 10 dB increase in the level of the noise and was unsatisfactory in noise conditions of 105 dB and 115 dB.

4. Electroacoustic measurements of the voicemitter responses affirmed the loss of high frequency acoustic energy that was suggested by the psychoacoustic measurements.

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- 2 American National Standards Institute. "Specifications For Audiometers", ANSI S3.6-1969.
- 3 McKinley, R.L. "Voice Communication Research and Evaluation System", AMRL TR-80-25, 1980.
- 4 USAF Bioenvironmental Noise Data Handbook, F-15A Aircraft, Near and Far-Field Noise, Volume 63, AMRL TR-75-50, November 1975.
- 5 "Hazardous Noise Exposure", U.S Air Force Regulation 161-35, April 1982.



Figure 1

MCU-2/P All-Purpose Chemical Defense Protective
Mask with and without the protective hood.



Figure 2

Voice Communication Research and Evaluation
System (VOCRES).

SPECTRUM F-15A

F100-PW-100(1) ENGINE

OPERATION

FAR FIELD NOISE

**80% RMP
BOTH ENGINES
FREE FLOW**

DISTANCE FROM AIRCRAFT = 75 METERS

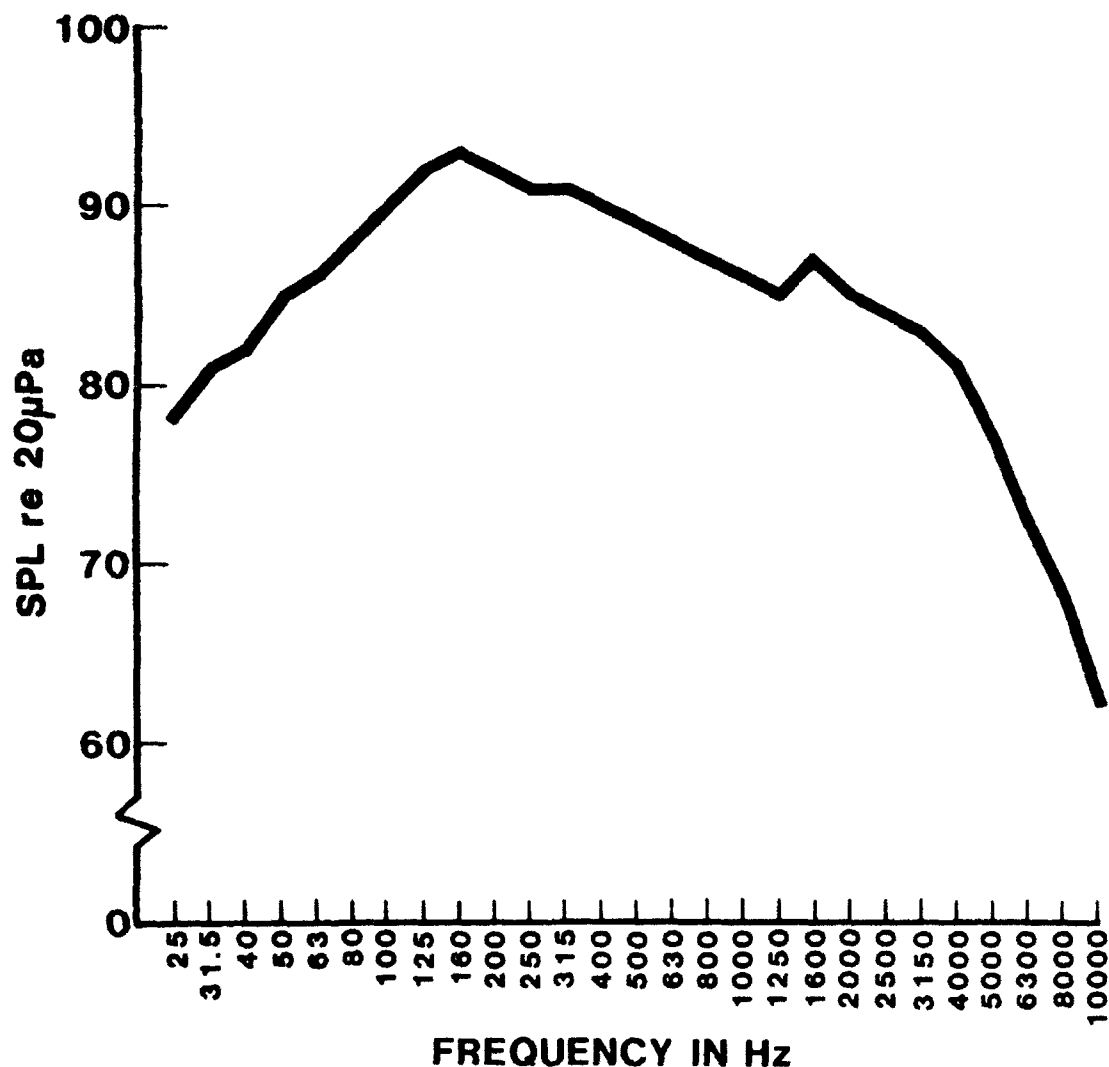


FIGURE 3

**FAR FIELD-NOISE SPECTRUM OF AN F-15A TACTICAL
AIRCRAFT EMULATED IN THE LABORATORY FOR THE
NOISE CONDITIONS OF THIS RESEARCH.**

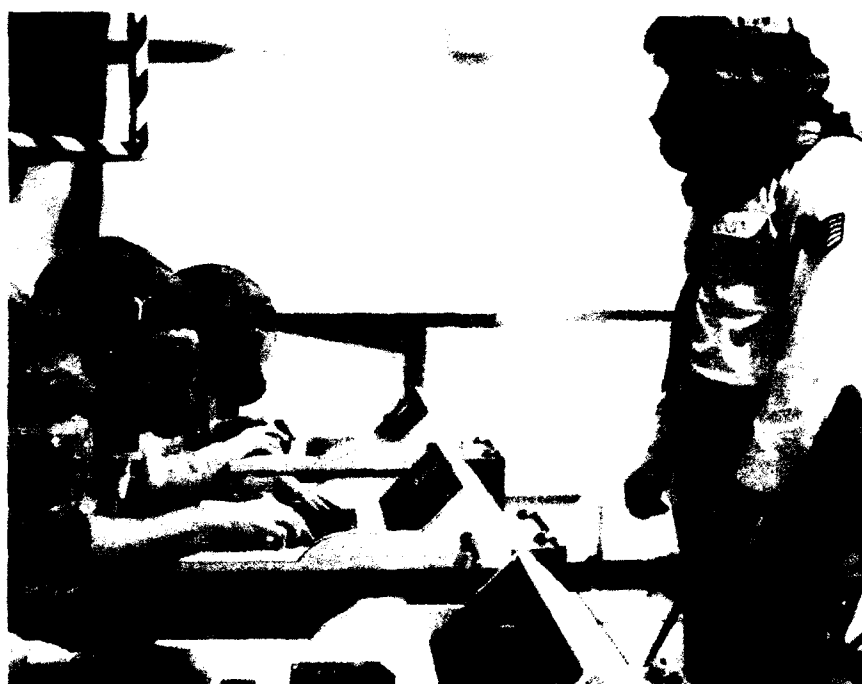
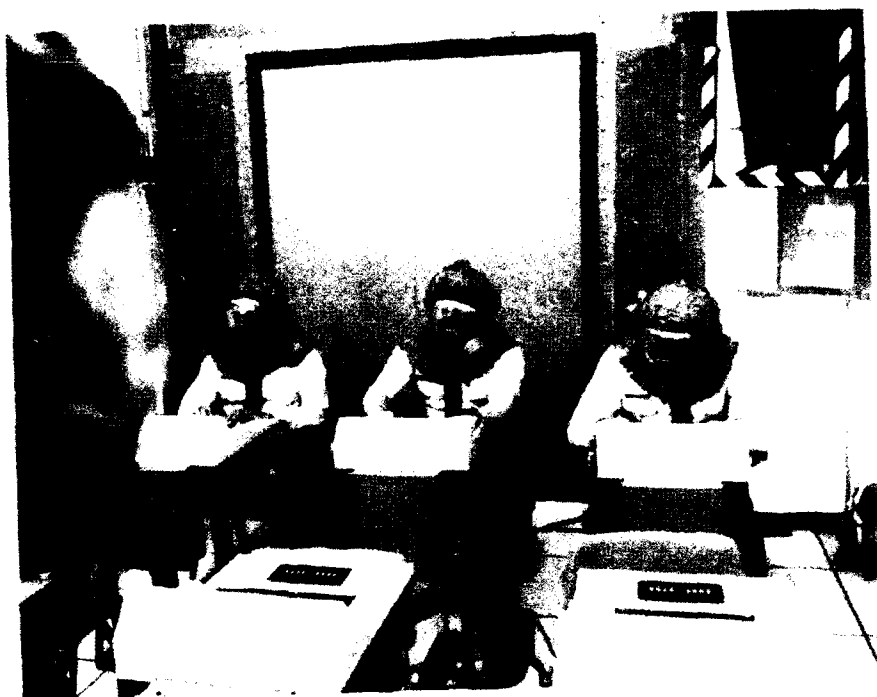


Figure 4

Face-to-face evaluation with talker facing three listeners seated at communication consoles. Consoles contained multiple choice response sets and a subject response unit.



Figure 5

The MCU-2/P mask/hood and telephone handset interface. Subject maintained a tight coupling of the telephone mouthpiece to the small voice emitter during tests.



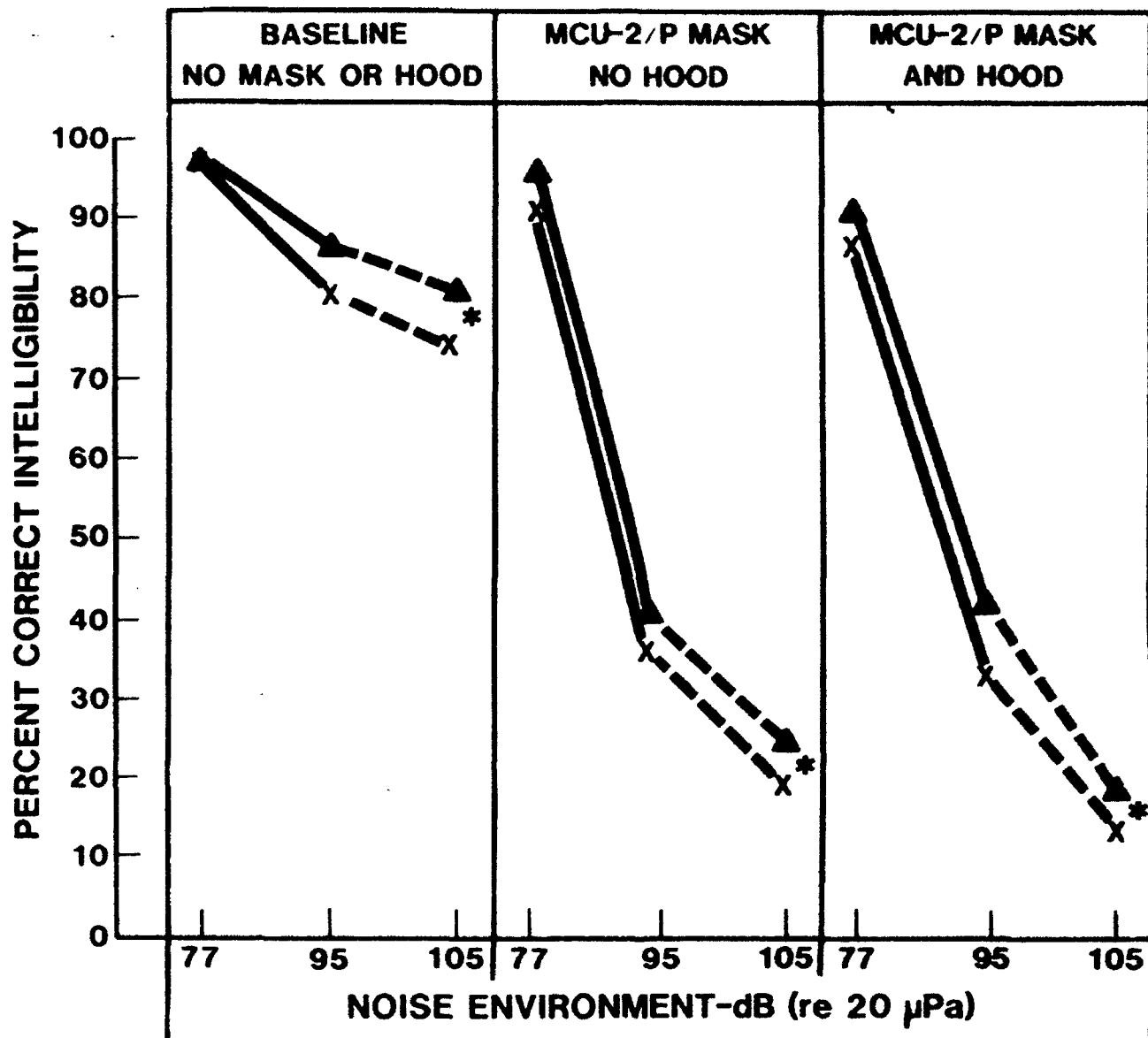
Figure 6

The MCU-2/F mask/hood and "walkie-talkie" interface. A good acoustic fit and coupling could not be achieved between the walkie-talkie unit and the vocemitter.



Figure 7

The MCU-2/P mask/hood and H-133 headset-microphone interface. The talker positioned the "tear-drop" noise shield directly over the large voicemitter.



* NOTE - AT NOISE LEVELS OF 105dB SPL, SUBJECTS WORE BILSOM UV-1 EARMUFFS IN COMPLIANCE WITH AFR 161-35 HAZARDOUS NOISE EXPOSURE.

▲ — — — ▲ 3 FT SEPARATION
 X — — — X 10 FT SEPARATION

FIGURE 8

FACE-TO-FACE COMMUNICATIONS. PERCENT CORRECT INTELLIGIBILITY SCORES AS A FUNCTION OF COMMUNICATION CONFIGURATION, SEPARATION DISTANCE AND NOISE CONDITION

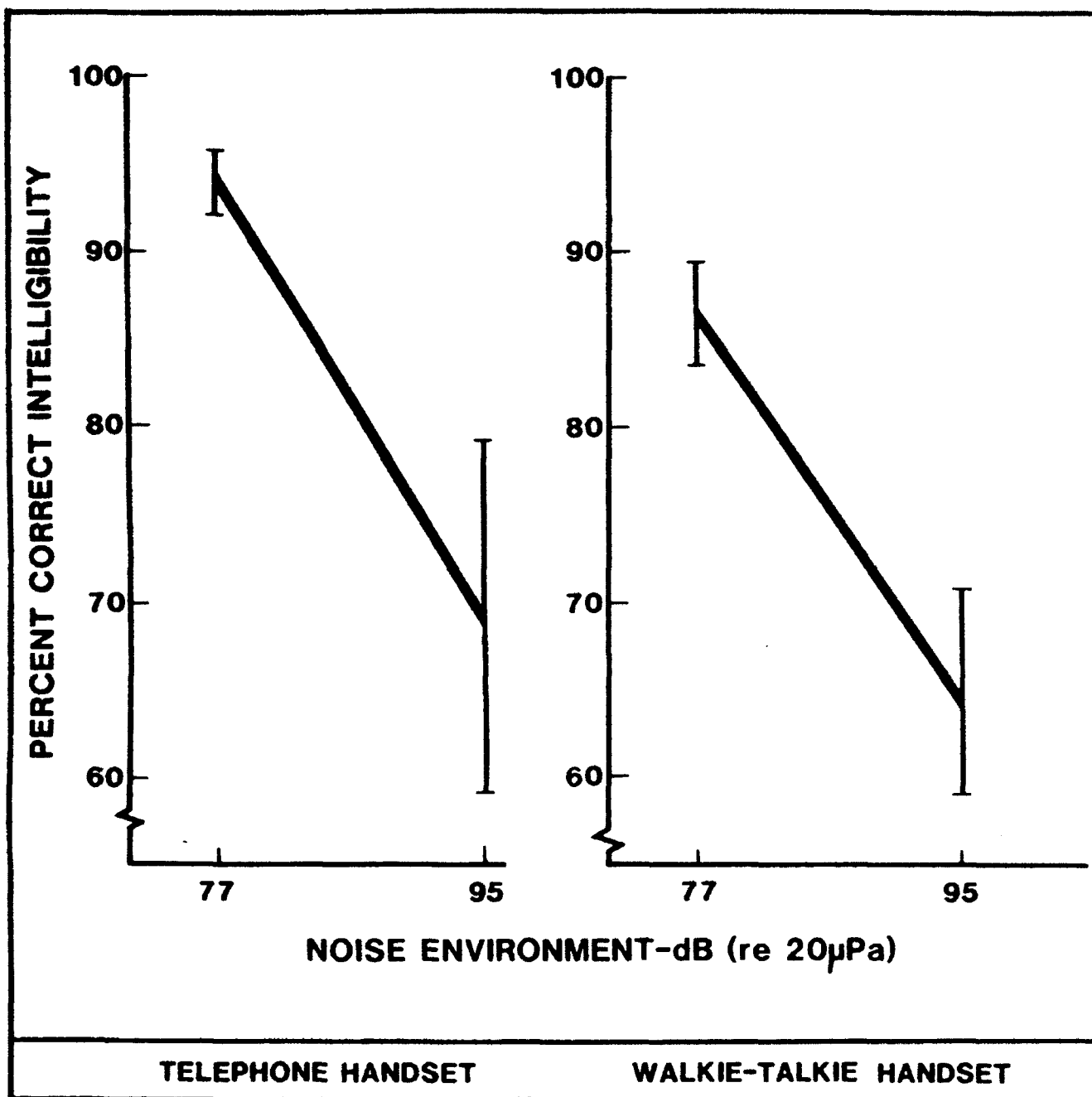


FIGURE 9
VOICE COMMUNICATION PERFORMANCE (± 1 STANDARD DEVIATION) OF THE MCU-2/P MASK AND HOOD WITH THE TELEPHONE AND "WALKIE-TALKIE" HANDSETS IN THE NOISE ENVIRONMENTS.

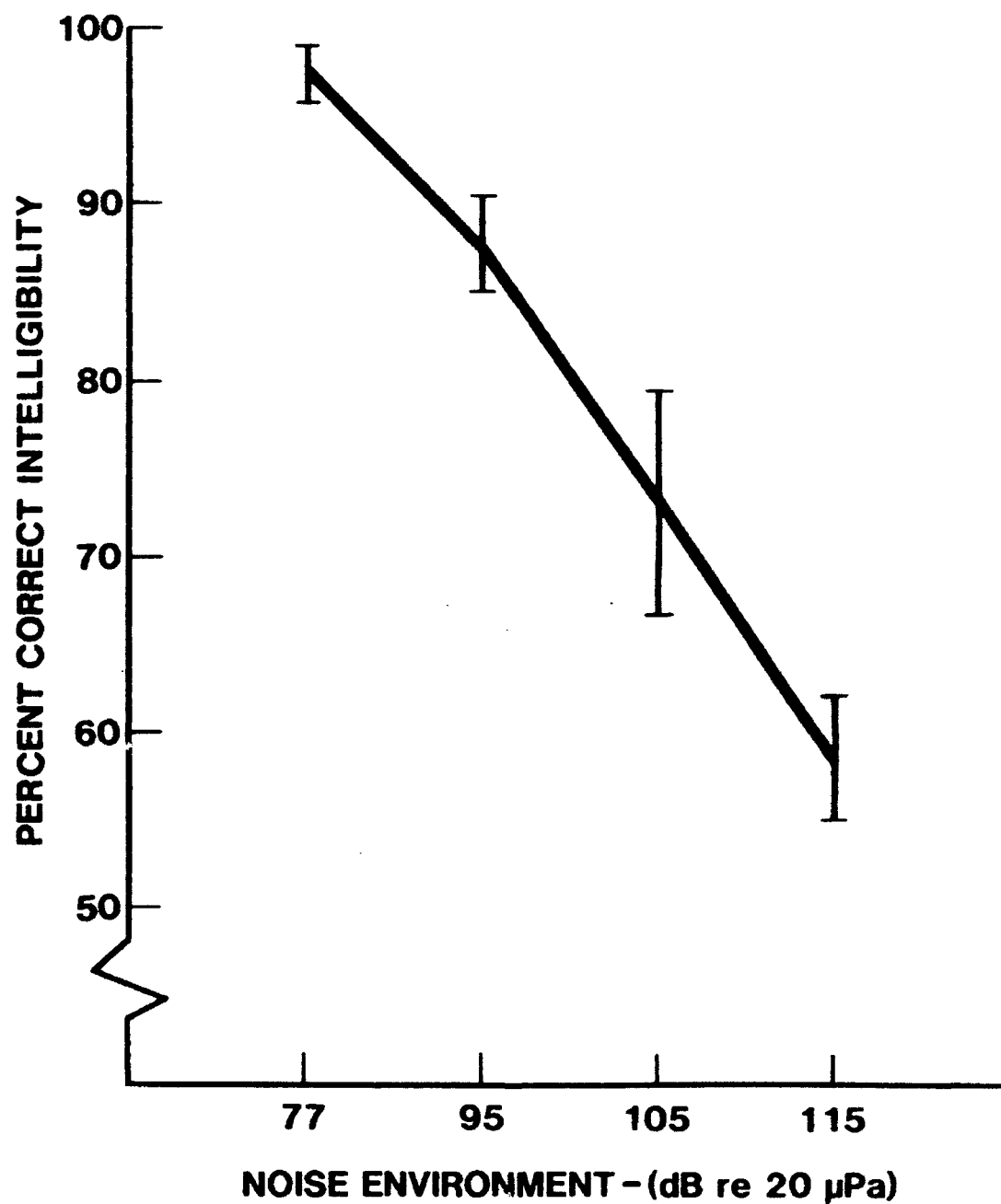


FIGURE 10

**SPEECH INTELLIGIBILITY (± 1 STANDARD
DEVIATION) OF THE MCU-2/P MASK/HOOD
AND THE H-133 GROUND COMMUNICATIONS
HEADSET-MICROPHONE IN FOUR NOISE
ENVIRONMENTS**

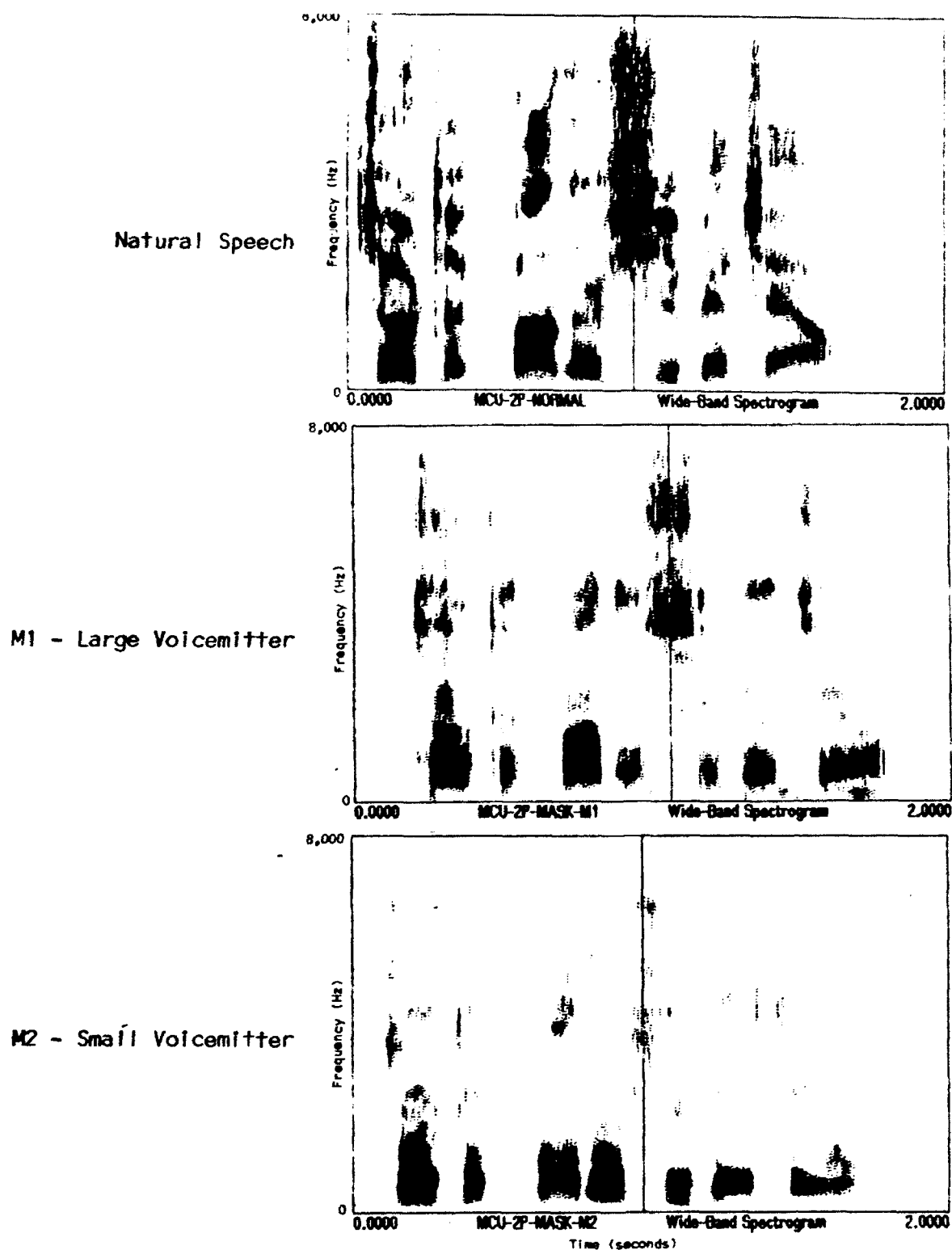


Figure 11. Speech spectrograms of the phrase "Joe took father's shoe bench out" for natural speech, the large voicemitter and the small voicemitter.

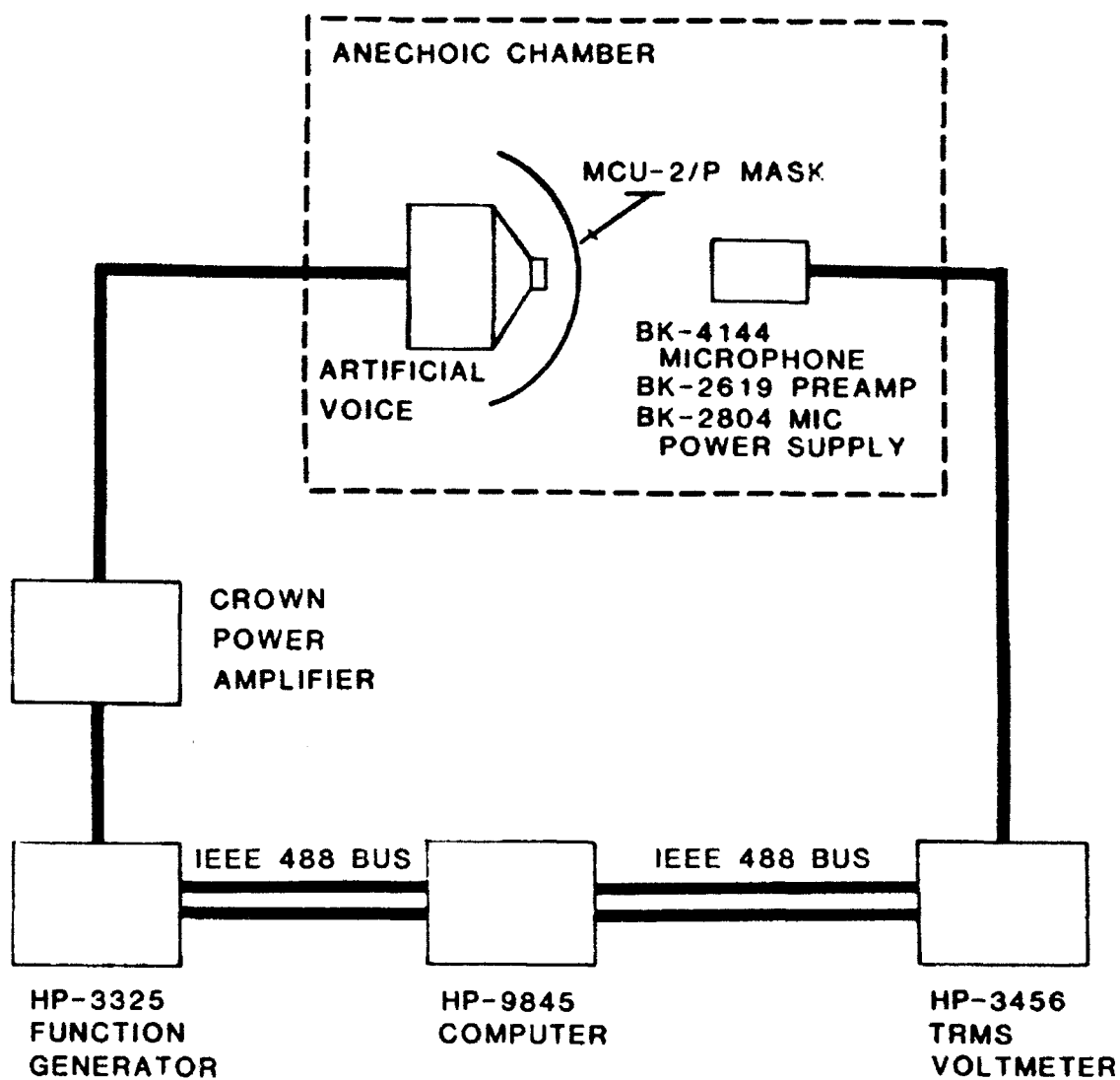


FIGURE 12

INSTRUMENTATION FOR MEASURING THE FREQUENCY RESPONSE OF THE MCU-2/P VOICEMITTERS

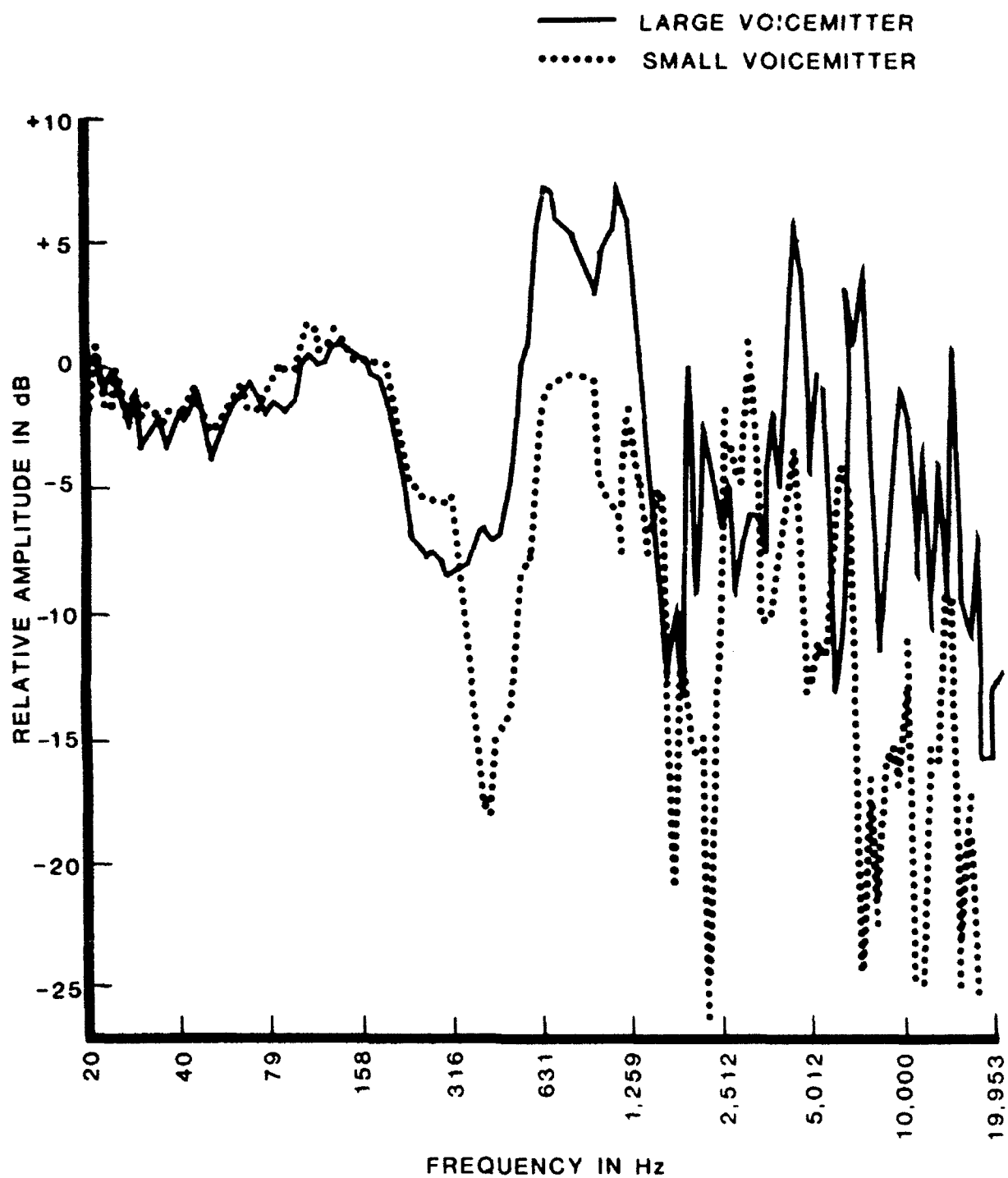


FIGURE 13

NORMALIZED FREQUENCY RESPONSES OF THE MCU-2/P MASK LARGE AND SMALL VOICEMITTER.

TABLE 1

**SELECTED NOISE LEVELS IN WHICH MCU-2/P MASK
COMMUNICATION CONFIGURATIONS WERE EVALUATED**

	AMBIENT	F-15 SPECTRUM		
	77 dB	95 dB	105 dB	115 dB
FACE-TO-FACE COMMUNICATION	X	X	X*	
COMMERCIAL TELEPHONE HANDSET	X	X		
SECURITY POLICE "WALKIE-TALKIE" HANDSET	X	X		
H-133 GROUND COMMUNICATION HEADSET	X	X	X	X

*** SUBJECTS ALSO WORE AN AF STANDARD EARMUFF
HEARING PROTECTOR**

		NOISE ENVIRONMENT					
		FARFIELD SPECTRUM F-15					
CONDITION	TALKER	77 dB		95 dB		105 dB	
		3'	10'	3'	10'	3'	10'
Without MCU-2/P Mask and Hood	1	49.3 47.7	49.3 49.3	45.3 41.0	42.3 42.3	40.3 33.3	41.7 36.7
	2	49.7 49.3	49.0 49.0	43.7 40.3	38.3 42.7	42.7 41.0	37.7 35.7
	3	48.0 48.7	49.0 47.7	42.3 46.0	41.7 37.7	44.0 40.0	42.7 39.3
	4	49.0 50.0	50.0 49.0	46.0 43.7	44.0 39.0	42.0 43.7	38.0 40.7
	5	50.0 49.3	49.0 49.7	43.3 44.3	45.7 43.3	39.0 46.3	41.3 39.3
	AVG	49.1	49.1	43.6	41.7	41.8	39.1
	% corr	97.8	97.8	84.6	80.1	80.4	73.9
MCU-2/P Mask without Hood	1	47.0 49.0	45.0 47.3	30.3 28.7	31.3 23.0	17.7 17.7	15.3 15.0
	2	46.7 50.0	46.7 47.0	21.7 21.3	23.3 22.7	17.7 14.7	8.7 15.0
	3	47.3 44.7	47.3 46.3	20.3 28.3	18.3 24.3	12.7 17.0	13.0 20.7
	4	50.0 47.7	49.7 48.0	24.0 26.7	18.7 25.7	22.0 19.7	16.3 20.7
	5	49.7 49.0	45.0 47.7	26.0 25.7	27.7 21.3	20.0 28.0	20.7 16.0
	AVG	48.1	47.0	25.3	23.6	18.7	16.1
	% corr	95.5	92.8	40.7	36.7	24.9	18.7
MCU-2/P Mask and Hood	1	47.7 48.0	43.7 44.3	27.3 31.3	24.0 18.0	14.7 14.7	14.7
	2	49.0 44.3	42.3 44.3	21.0 20.3	19.7 20.7	13.7	15.3
	3	43.7 44.7	42.0 46.0	26.0 30.7	23.7 24.7	18.7	14.7
	4	48.3 48.3	45.0 46.7	26.0 30.3	23.7 22.3	14.0 16.3	15.3
	5	47.0 49.0	48.3 45.3	21.0 24.0	23.3 20.0	18.0	15.7
	AVG	47.0	44.8	25.8	22.0	15.9	15.1
	% corr	92.8	87.5	41.9	32.8	18.2	16.3

TABLE 2 Raw Data - Face-to-Face Audio Communications Configurations

		NOISE ENVIRONMENT	
			F-15 Spectrum
CONDITION	TALKER	77 dB	95 dB
MCU-2/P Mask communicating through telephone instrument	1	46.2	38.2
	2	47.4	41.4
	3	47.6	30.8
	4	48.2	35.4
	5	48.0	39.8
	AVG	47.5	37.1
	% corr	93.9	69.1
MCU-2/P Mask communicating through Walkie- Talkie radio	1	43.0	35.2
	2	45.4	38.4
	3	43.0	33.6
	4	45.0	31.6
	5	45.2	37.0
	AVG	44.3	35.2
	% corr	86.4	64.4

TABLE 3

Raw Data of the Speech Intelligibility of the MCU-2/P Telephone Handset and the "Walkie-Talkie" Interface Audio Communications Configurations

		NOISE ENVIRONMENT			
		FAR FIELD F-15 SPECTRUM			
CONDITION	TALKER	77 dB	95 dB	105 dB	115 dB
MCU-2/P Mask and Hood communicating through H-133 head-sets	1	48.8 47.6	46.1 44.3	43.1 39.5	34.0 34.6
	2	49.0 49.6	44.1 43.3	38.9 39.3	32.5 30.3
	3	49.1 49.5	45.3 46.4	37.5 34.4	33.0 32.1
	AVG	48.9	44.9	38.8	32.8
	% corr	97.4	87.8	73.1	58.6

TABLE 4

Raw Data of the Speech Intelligibility of the MCU-2/P and H-133
Ground Communications Headset Interface Communications Configurations